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COMMANDER'S DIGEST
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DARPA

An Investment Strategy for the Late 70s

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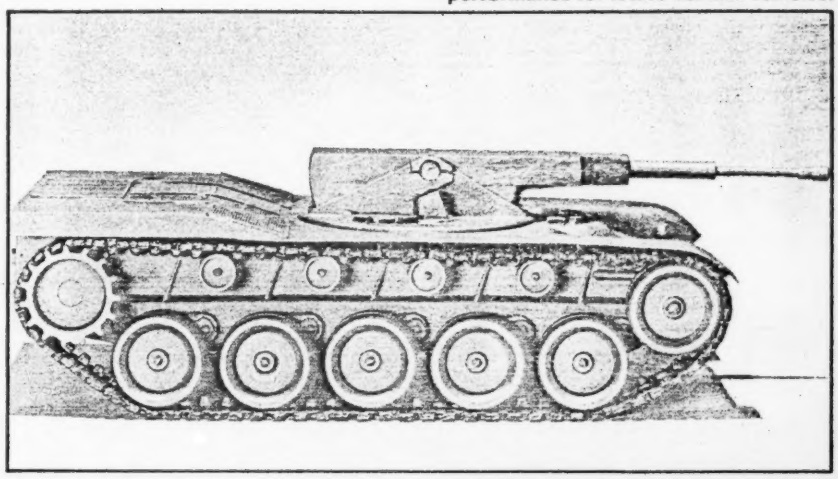
The Role Of

DARPA high mobility/agility test vehicle (HIMAG) mounting 75mm hypervelocity automatic cannon. HIMAG is a variable parameter test vehicle capable of varying engine HP, weight, suspension system and fire control components to determine essential performance for future combat vehicles.



The purpose of this article is to map out where the Defense Advanced Research Projects Agency (DARPA) is headed, not only in the next year, but for the next three years. I hope to give you a feel for our investment strategy and major thrusts.

DARPA is entrusted with the corporate, or central, research function of the Department of Defense. The reasons why such a function is needed in the Department of Defense, in addition to the Service Research and Development (R&D) activities, are the same reasons as those that justify the central research activities of major corporations, in the presence of other R&D activities conducted in the various separate divisions of these large corporations. In brief, the Secretary of Defense, like his corporate counterparts, needs a flexible organization such as DARPA, reporting at the highest levels, working at the cutting edge of technology, and not encumbered by vested interests or roles and missions dogma.

Key Questions

As one looks to the future, there are key technical questions which must be answered if the United States is to protect itself from technological surprise that could threaten its security—surprises that could be far less benign than Sputnik, which, incidentally, precipitated the formation of DARPA in 1958 with a charter to pursue technological initiative and prevent technological surprise. The DARPA investment strategy is focused on providing the Nation with a long lead-time and some of the background data which decisionmakers need in order to answer questions which could become the national security issues of the late 1970s. There are many questions of this nature, some of which are:

- Is a space-related use of high energy lasers possible and could it threaten our vital satellite network and strategic deterrent capability? Conversely, could such a laser serve the United States in some other defense way?
- Are there technologies on the horizon that can provide space-based surveillance capable of detecting aircraft and warning of missile launches?
- Is a new class of undersea surveillance systems possible that could locate submerged submarines at great range with sufficient accuracy to target them? What are the limits of ocean hearing? Can the oceans really be made "transparent?"
- What is the nature of armor on the battlefield of the future? Are there technologies that could permit unique trade-offs between mobility, agility, armor and firepower that could result in a new and better class of lower-cost armored vehicles?
- What can technology do about the seemingly endless spiral of increasing costs? For example, can we dramatically reduce the cost of jet engines by making them out of new types of ceramics instead of costly metallic superalloys? Can the sophistication and low cost represented by the pocket calculator and digital watch be used to simplify the maintenance problems of our equipment and make it more reliable?
- Are there technological initiatives in the command and

control area that could enable us to use our current forces more effectively?

- Are there technological breakthroughs possible which could lower the cost or greatly increase the speed, range and endurance of undersea vehicles?
- Is it possible for an adversary to sign nuclear test ban treaties and then covertly test nuclear weapons?

If the answers to these questions are "yes", and others find the way before we do, our security will be gravely endangered and our ability to deter conflict greatly weakened. The questions are not entirely new. What is new is the fact that, in my opinion, this is indeed a unique time; I cannot recall a period in the past decade when so many technological breakthroughs with potential major impact on national security were on the horizon.

The Major Thrusts

DARPA tends to select its programs based on the generation or emergence of a new technological approach or idea which, over the long haul, could lead to a major payoff in national security. In addition, DARPA is sometimes the mechanism by which diverse technical specialties are brought together to focus on a problem while, at other times, it serves as a technical catalyst to take a fresh look at activities in older areas where initiative is needed. DARPA makes no open-ended commitments, nor are we a science-for- science-sake organization. DARPA exists to generate, focus, catalyze, organize, execute, evaluate and transition to the Services proven concepts. These can form the basis of development programs that can make a major difference to national security.

I would like to outline the major thrusts of DARPA's program—a program that we believe represents our best investment strategy for the late seventies. I would like to sketch the technological breakthrough areas which are a major part of our program, together with mission initiatives which underlie their importance to our future security. You will see how we focus our efforts to address key questions in the areas of space defense, undersea surveillance, undersea vehicles, battlefield vehicles, command and control, and lowering the cost of national defense, as well as seeding new technological ground for the future.

By Dr. George H. Heilmeier
Director, Defense Advanced Research Projects Agency (DARPA)

DARPA

Space Applications

In the area of space applications, there are three major technological initiatives that DARPA has pioneered:

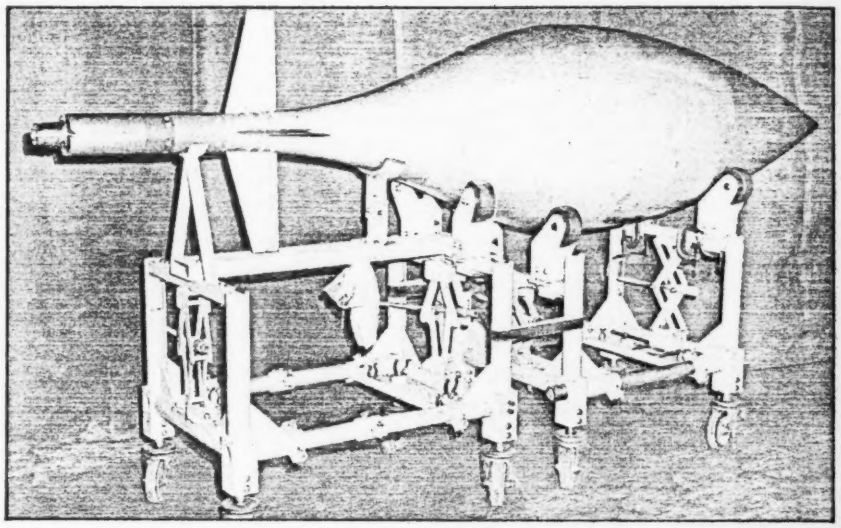
- The high energy chemical laser.
- Monolithic infrared sensor systems based on silicon charge coupled device technology.
- Adaptive optics.

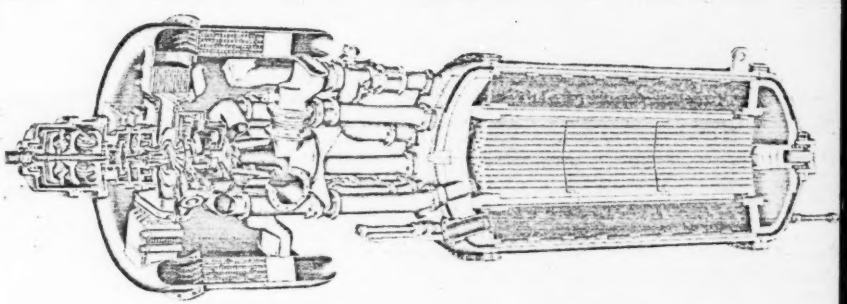
The high energy chemical laser, because of its higher mass efficiency and ability to produce laser power without a large electrical power supply, could lead to a device whose size and weight would enable it to be used in space. DARPA pioneered high energy chemical laser technology and is now exploring the technical problems of extending the concept to operation in a space environment.

In the area of infrared sensors, we believe that DARPA has found the key to applying the same mass production technology of silicon integrated circuits that made possible the pocket calculator to the problem of infrared surveillance from space. This means that it may be feasible to make space systems with millions of integrated infrared sensors instead of a few thousand hand-wired detectors. Such capability might lead to an ability to detect aircraft from space as well as missile launches.

Fundamental to many types of surveillance and space laser systems is the need to assemble large optics in space or to compensate for atmospheric turbulence and optical system changes. In DARPA's pioneering work on adaptive optics, it is pursuing ways to compensate in real-time for atmospheric turbulence that can distort images or the imperfections of large optical systems which result from the incompatibility between large size and the requisite precision. The adaptive optics work has been very promising to date, and currently being assembled are proof-of-principle models in large sizes.

Vehicle B-1 Prototype—A laminar flow vehicle using pressure-gradient control.





A 40 HP closed Brayton cycle engine with a stored thermal energy heat source.

Undersea Vehicles

DARPA has been responsible for a major breakthrough in undersea vehicle design—DARPA has learned how to lower the drag (i.e., friction) on such vehicles and has demonstrated the principle. Drag

is a fundamental, limiting factor on such vehicles because it ultimately determines the vehicle's speed, range and endurance.

Undersea Surveillance

Through DARPA-sponsored experiments, the ocean has been found to be a far more tractable underwater sound environment than was previously thought. Improved detection ranges appear to be achievable. The signal processing techniques which are being explored show promise and DARPA is now attempting to demonstrate an improved capability for finding submarines. If successful, these experiments could lay the groundwork for an advanced submarine detection and localization system.

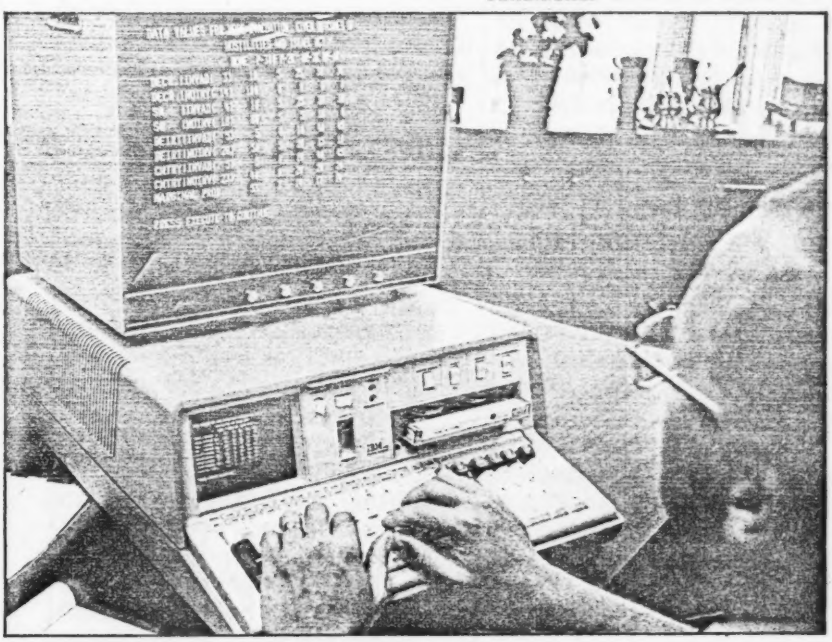
Land Combat

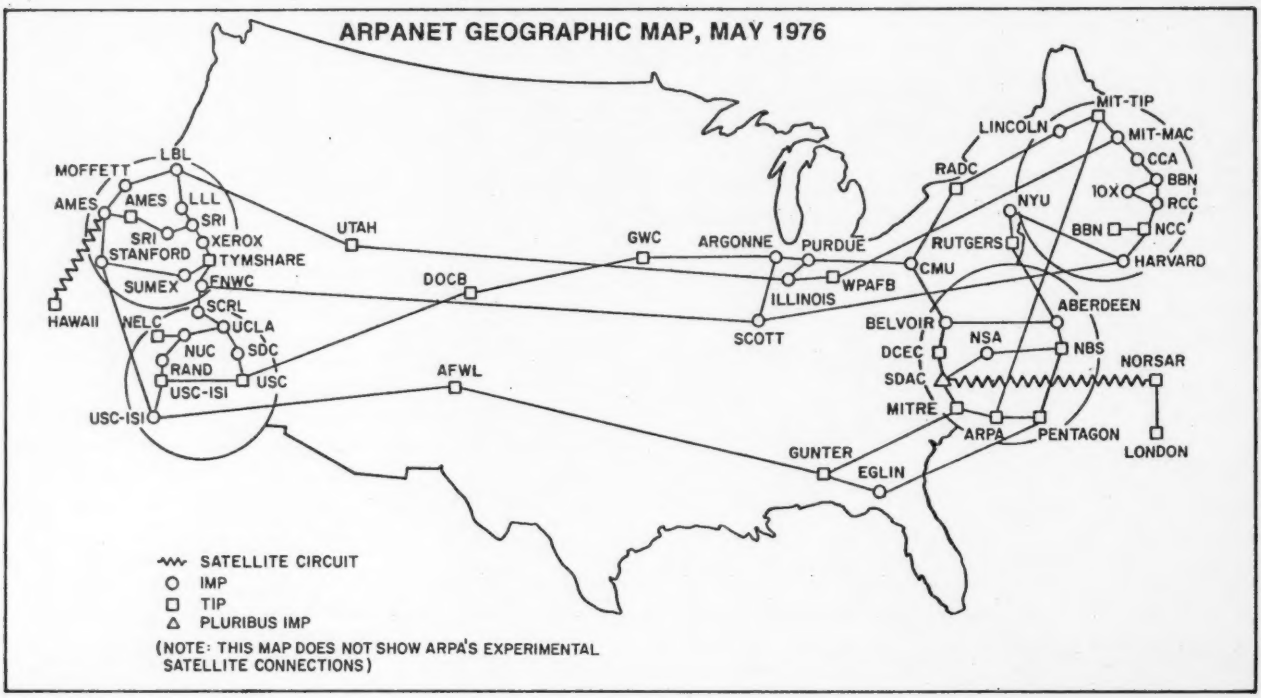
The size of a tank, and hence its cost, is usually dominated by the size of the gun. Results from DARPA's gun programs, when coupled with an advanced rod-like penetrator, may enable the fabrication of an anti-tank "machine gun". This high-risk program represents a breakthrough in gun technology. DARPA also is attempting to quantify, by means of a test bed, the trade-offs between mobility, agility, survivability and fire power that this gun development might make possible. Perhaps in the late 1980s or early 1990s it will be possible to make more survivable armored vehicles of smaller size, lower cost and greater fighting capability. However, more data are needed and the program is designed to accomplish this task.

Command and Control

Command and control is the linkage by which the effective use of U.S. forces is coordinated. Any weapon system, no matter how great its capability, needs to be coordinated with other battlefield assets if it is to realize its full mission capability. Fundamental to the command and control process are the building blocks of computers, data bases, data handling techniques, data security and networking. DARPA is exploring the technology which permits remote conferencing, effective interactions between computers, shared use of distributed computers, and simplified user-to-user message handling. DARPA is also exploring techniques that make it more difficult for an enemy to

The combination of advanced decision aids, developed under DARPA support, and new mini-computer technology now make it possible to develop and use, in near real-time, models that can assist decision makers to consider complex alternatives under crisis conditions.





SATELLITE CIRCUIT
IMP
TIP
PLURIBUS IMP
(NOTE: THIS MAP DOES NOT SHOW DARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)

locate communications and either intercept, jam or target them. Software is a pacing element in command and control and ways are being explored to simplify the complex process of generating computer software by involving the computer itself more directly in the generation, verification and documentation processes through a set of tools that can be made widely available by means of computer networking.

While the technology building blocks which are being explored are important to any command and control system, DoD needs better ways of understanding total system needs and management/technology/personnel trade-offs in the command and control process. Thus, DARPA plans to utilize some of its existent network technology (which it pioneered in the ARPANET) as a flexible test bed capable of exercising realistic command and control scenarios by the users, not the engineers. This test bed will enable users to experiment with various system architectures and assess the impact of new technology, such as speech inputs in computers and intelligent terminals, in real command and control scenarios while injecting the all-important human factors.

Lower Defense Costs Through Technology

In the past, DARPA's efforts have been almost exclusively focused on increasing capability and performance. In this era of tight budgets, however, it faces a dual challenge in reducing costs as well as improving performance. It is now attempting to apply some of the technological initiative and

imagination which has always characterized DARPA programs to the objective of dramatically lowering the cost of materials, manufacturing and maintenance. Following are some examples of what DARPA is doing.

The efficiency of gas turbine engines is determined by the temperature at which they operate. Today's highest performance jet engines use exotic and expensive superalloys to operate at metal temperatures of about 2000°F. DARPA is exploring the use of ceramics as a substitute for superalloys in such turbines. Ceramic turbines use materials which are cheap, plentiful and easy to fabricate. In addition, they should be capable of operating at component temperatures of 2500°F. The successful demonstration of a 2500°F ceramic turbine could revolutionize the military engine business, thanks to its greater efficiency and ability to use a wider range of fuels. Indeed, it may have important implications for the entire Nation.

This is but one example of how DARPA is applying the revolutionary versus evolutionary approach. Some others include:

- Rugged (boron nitride) tooling for machining superalloy parts for jet engines to reduce superalloy machining costs by an order of magnitude.
- Superalloy molds to replace sand molds in the casting of ferrous metals. This approach, based on the thixotropic properties of ferrous alloys, makes it possible to automate the casting processing (superalloy molds are reusable). In addition, this process results in a cast part that has a machined-like surface, thus obviating the need for further expensive machining in many applications.
- Novel quantitative nondestructive inspection techniques to reduce the burgeoning costs of quality assurance on high performance vehicles.
- Low cost mini-Remotely Piloted Vehicles (mini-RPV) and distributed sensor systems. The cost of the vehicle and its sensor systems can be greatly reduced by decreasing the size of the vehicle, not requiring manned operation, and by placing critical components in a sanctuary or relatively safe areas and linking them via low cost, secure, jam-resistant data links. Thus, only the relatively inexpensive components need to be exposed and proliferated.
- Focusing on some seemingly neglected areas of military manpower such as training and evaluating men as teams instead of individuals, exploring novel ways to train maintenance personnel and exploring the limits of the computer in training and evaluation functions.

Laying the Groundwork

The preceding six items represent technology focused at answering penetrating questions fundamental to an ability to prevent technological surprise and face an uncertain future. The answers lie in the exploration of high-risk/ high-payoff technology that is often revolutionary. But DARPA continues to be an incubator for ideas in other areas as well. These include seed efforts in such areas as:

- Sensor and processor technology that would enable drones to seek out and attack specific classes of targets.
- Laser propulsion utilizing ground-based high energy lasers that could lead to much lower launch costs for the relatively small space packages of DoD interest.
- X-ray lasers.
- Organic conductors (lighter weight, noncritical materials).
- Exploring the world of electronic materials beyond the present silicon-based technology—binary semiconductors for microwave, night vision and electro-optic applications.
- Applying computer-based artificial intelligence concepts to problems in anti-submarine warfare (ASW) and electronic warfare (EW).
- Biocybernetics—to integrate man with computers and control systems more closely.
- High density computer memories (10^8 bits/cm^2 or 100 million pieces of information on a chip the size of a fingernail).
- Intelligent computer terminals that remember the protocols for use of various data bases, pursue goals over time and adjust to operator nuances, etc.
- Self-initiated missiles that launch on specific target signatures.

Summary

DARPA will continue to be a place where new ideas and concepts are welcome; where businessmen's risks are taken; where an idea can be matured. DARPA is the cutting edge for the kind of new technology that can provide the United States with options for major increases in or retention of deterrence in the face of the Soviet challenge. It has a major role in maintaining the technological initiative. The United States is number one

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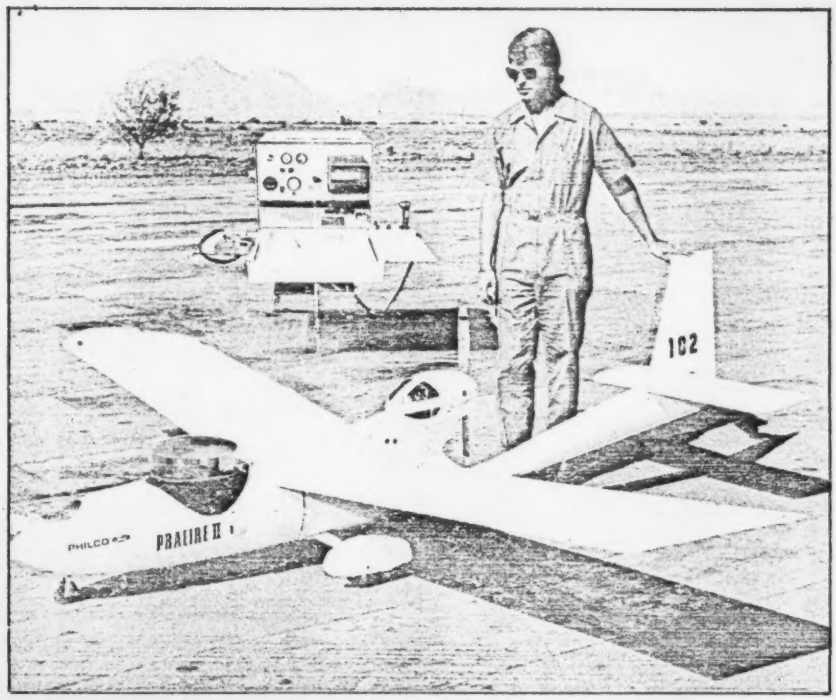

The PRAEIRE II RPV is a low cost system designed for target acquisition and designation for guided weapons. High volume production techniques and minimal complexity in the airborne subsystems are the keys to low system cost.

today because of DARPA's unique ability to put imagination, technology and mission focus together. DARPA has a special role because of its unique charter, program, people and capabilities. This special role is clearly recognized by the Secretary of Defense and the Director of Defense Research and Engineering.

In order to gain the greatest possible leverage and benefit from limited resources, DARPA has prioritized its program into seven major thrusts. In the process, 61 programs representing $37 million were terminated, redirected or transferred. This was not an easy task in that less essential programs, each with its own capable spokesman and technical merit, had to be modified or terminated. It may not be successful in all its efforts, but it now has an investment strategy that maximizes opportunities for a high return on investment in terms of options for major new capabilities, even if it succeeds in only a portion of its research and development efforts. It dares not preclude such options which could alter the military balance when they can be explored with minimal resource commitment and clear and discrete decision points concerning future full-scale development.

As pointed out earlier, DARPA is focused on obtaining data that will help decision makers to answer some of the key questions that could cloud this Nation's future security. The country needs the answers to these and other similar questions if it is to face an uncertain future with confidence in its own capability to respond to any threat to its security. DARPA is one of the mechanisms by which the answers are sought—not in rhetorical terms, but in terms of confirmed technological facts. Even if these questions are ignored, they will not go away. Others will find the answers and may even choose to use them for aggressive purposes. DARPA has structured an investment strategy that is designed to retain the technological initiative.

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